ECOLOGICAL INTEGRITY, A FOUNDATIONAL PRINCIPLE FOR FOREST PLANNING

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FMNF Sustainability Forum, Charleston, SC
August 6, 2013

Some identified goals and needs in developing “new” guidance

1. Emphasize restoration of natural resources to make NFS lands resilient to climate change, protect water resources, improve forest health
2. Contribute to ecological, social, and economic sustainability by ensuring that plans are responsive to issues such as
   - Climate change
   - Need for restoration and conservation
   - Sustainable use to support communities
3. Consistency with NFMA, MUSYA
4. All-lands approach (larger landscapes)

An ecosystem …

the collection of all the organisms that live in a given space and the abiotic environment they interact with.

…structured by

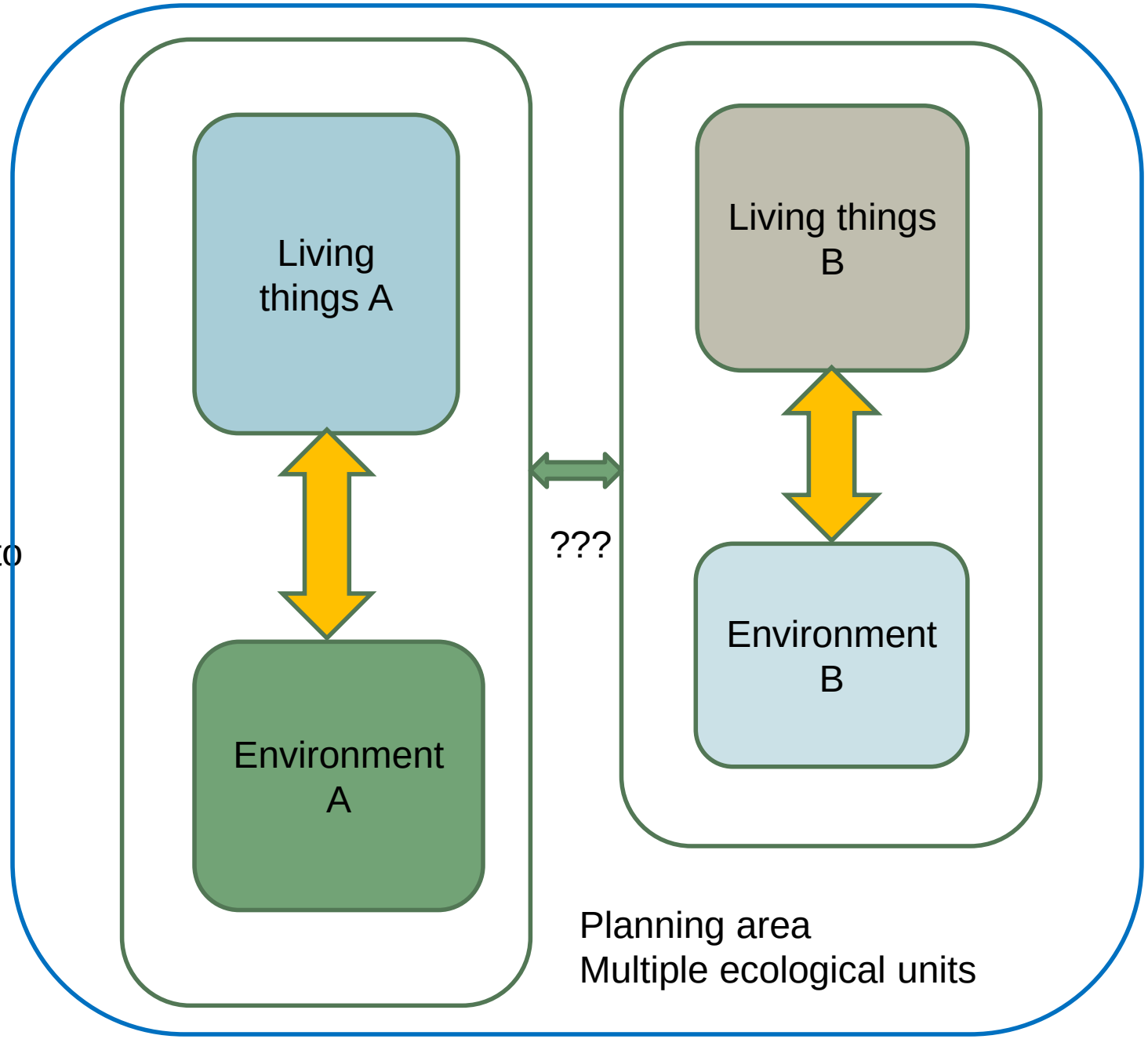
the availability of nutrients, the physical constraints the environment imposes, and relationships between different species

Ecosystem A
Is recognizable

- Species
- Physical environment

- Interactions similar
- From place to place

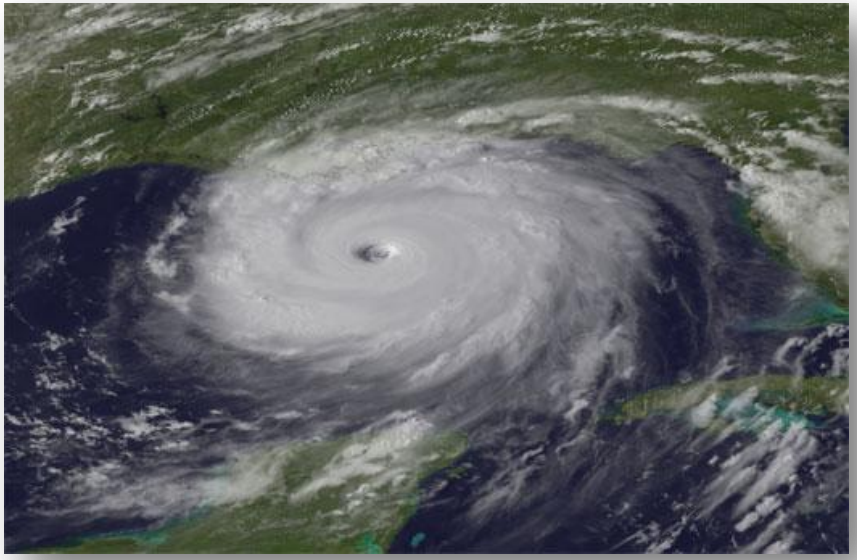
Ecosystem B
Is distinct



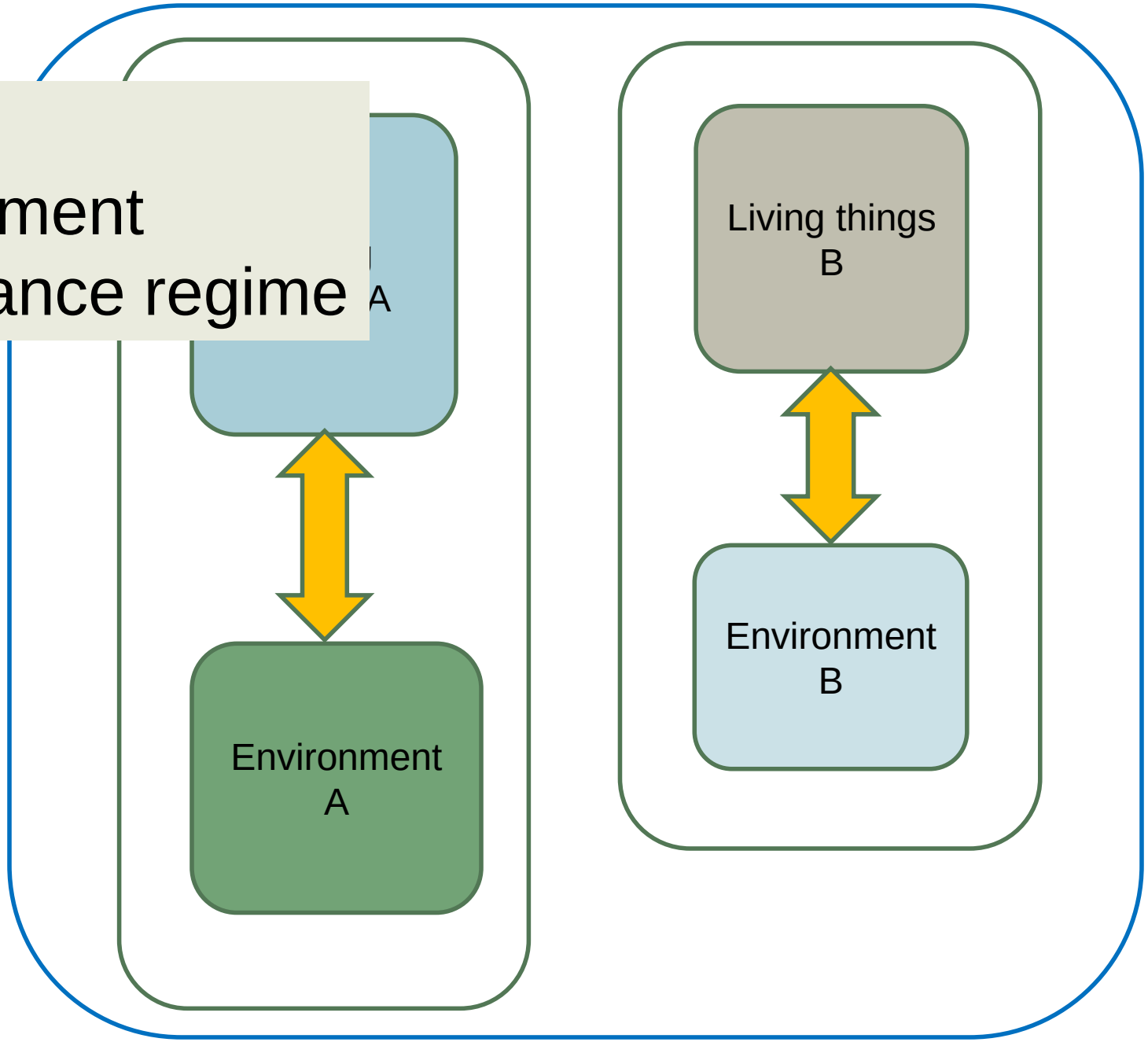
“dynamics of nature”

- Natural systems are inherently dynamic and repeated disturbance events are key to structuring ecosystems

- Patches of varying ages, sizes, shapes configurations
- Add complexity to ecosystem process: patch dynamics at different scales in time, space
- Landscape condition matters



Biota
Environment
Disturbance regime



Ecological integrity

- the ability of an ecological system to support and maintain a community of organisms that has a species composition, diversity and functional organization comparable to those of natural habitats within a region

A system has integrity when…

- its dominant ecological characteristics (e.g. elements of composition, structure, function, and ecological processes) occur within their natural ranges of variation

- can withstand and recover from most perturbations imposed by natural environmental dynamics or human disruptions (Parrish, Braun et al. 2003)

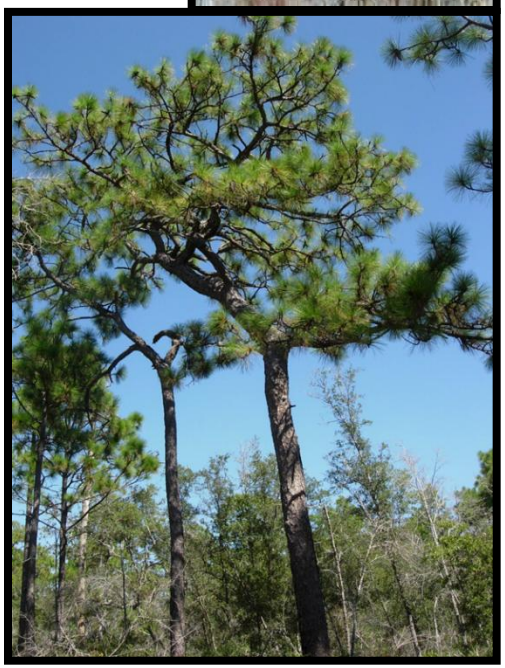
Ecological Integrity (Planning)

- “Refers to the quality of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation and can withstand and recover from most perturbation imposed by natural environmental dynamics or human influence”

- How do you do that?

Ecological attributes

Species composition
Population structure



Spatial pattern

Disturbance

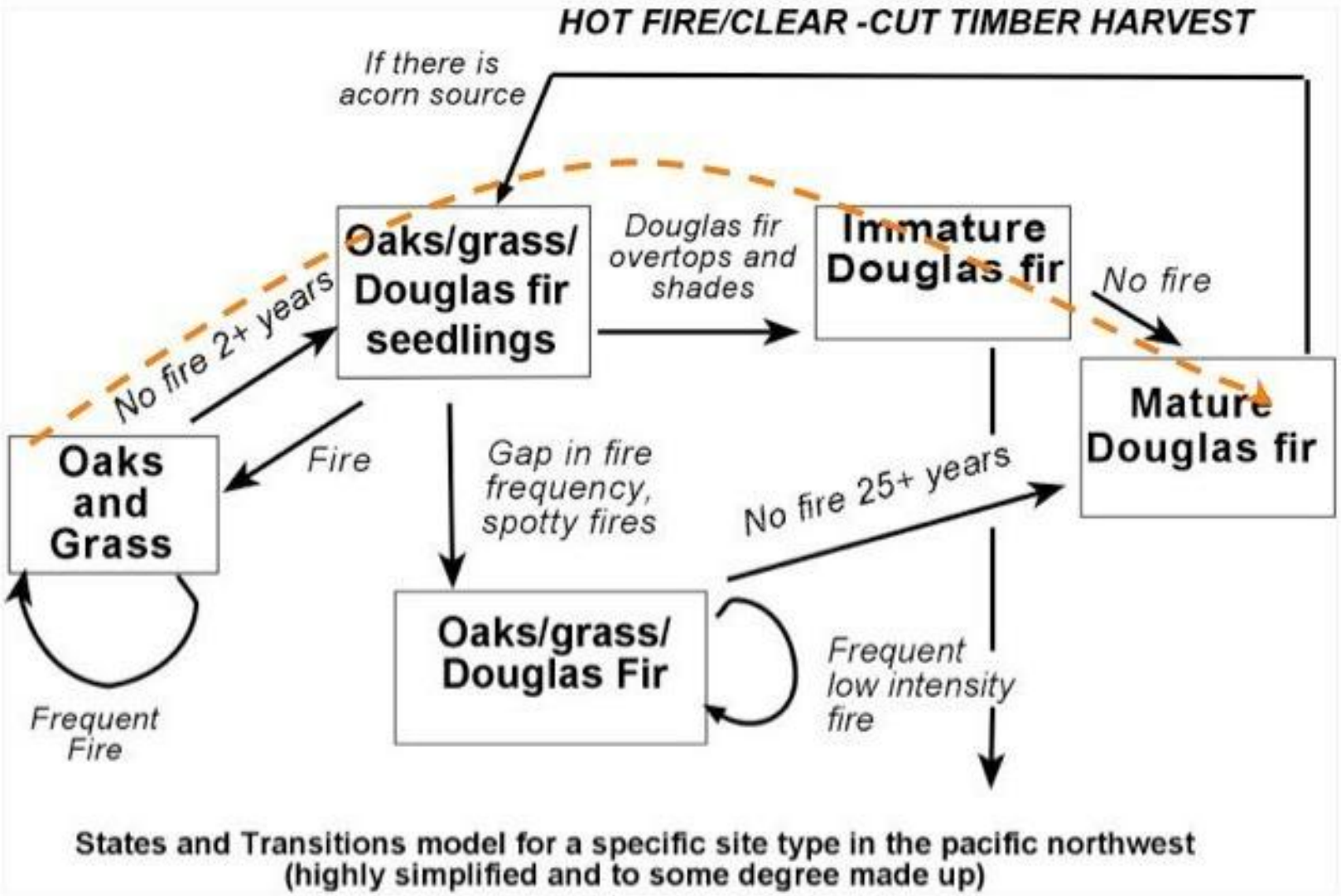
Key ecological attributes

- *a characteristic of the biology, ecology, or physical environment that is so critical to the system's persistence, in the face of both natural and human-caused disturbance, that its alteration beyond some critical range of variation will lead to the degradation or loss of the resource within decades or less.*

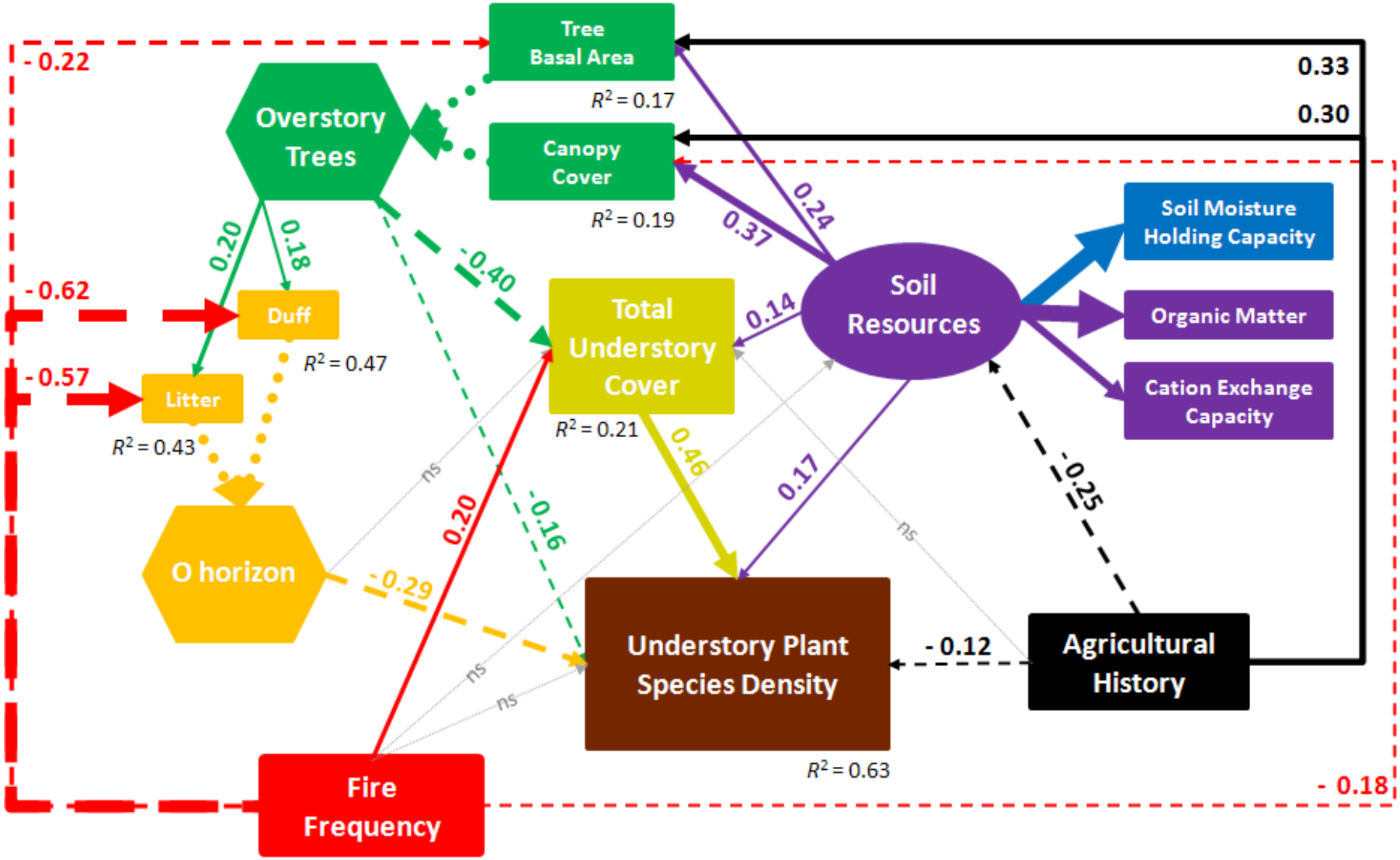
- *Fire in the upland longleaf pine ecosystem*

Role of conceptual ecological models

- Organize current knowledge of the system
- Develop hypotheses about how the system “works”, its defining characteristics and dynamic's, critical environmental conditions and disturbance regimes
- Hypotheses guide management, identify knowledge gaps
- Attributes also identify how a resource should be



States and Transitions model for a specific site type in the pacific northwest
(highly simplified and to some degree made up)


Tree Basal Area
R^2 = 0.17
Canopy Cover
R^2 = 0.19
Overstory Trees
- 0.22
0.33
0.30
0.24
0.37
0.20
0.18
-0.40
- 0.62
Duff
R^2 = 0.47
- 0.57
Litter
R^2 = 0.43
Total Understory Cover
R^2 = 0.21
0.14
Soil Resources
Soil Moisture Holding Capacity
Organic Matter
Cation Exchange Capacity
0.46
0.17
-0.25
ns
ns
0.20
-0.16
O horizon
-0.29
Understory Plant Species Density
R^2 = 0.63
- 0.12
Agricultural History
ns
ns
Fire Frequency
- 0.18

Key ecological attributes

Terrestrial

- *Environmental Disturbance Regimes*
- ✓Fire area/intensity regime
- ✓Wind disturbance regime
- ✓Precipitation & flooding extremes
- ✓Air temperature extremes
- ✓Geologic disturbances
- ✓Air quality, cloudiness

- *Connectivity*
- ✓Connectivity with adjacent systems (terrestrial, aquatic)
- ✓Connectivity among similar & different patch types within target system

Riverine

- ✓*Channel Morphology & Sediments*
- ✓Channel erosion-deposition, stability/instability
- ✓Channel shape, macrohabitat sequencing
- ✓Bed/bank porosity & texture
- ✓Bed/bank sediment chemistry
- Coarse organic matter

- *Connectivity*
- ✓Drainage/flow-path connectivity
- ✓Flood-zone inundation-recession connectivity
- ✓Surface-groundwater connectivity
- ✓Riparian corridor continuity
- ✓Riparian corridor-upland connectivity

Key attributes (cont.)

Terrestrial

- *Biotic Interactions, Composition, Structure*
- ✓ Keystone species and/or functional groups
- ✓ Rare/sensitive species or species groups
- ✓ Food web structure (guilds)
- ✓ Component communities & seral stages
- ✓ Spatial arrangement of key species & communities
- ✓ Migration-aggregation-dispersion
- ✓ Vegetation stratification & structure within patches
- ✓ Infestations & mass grazing
- ✓ Seed bank dynamics

Riverine

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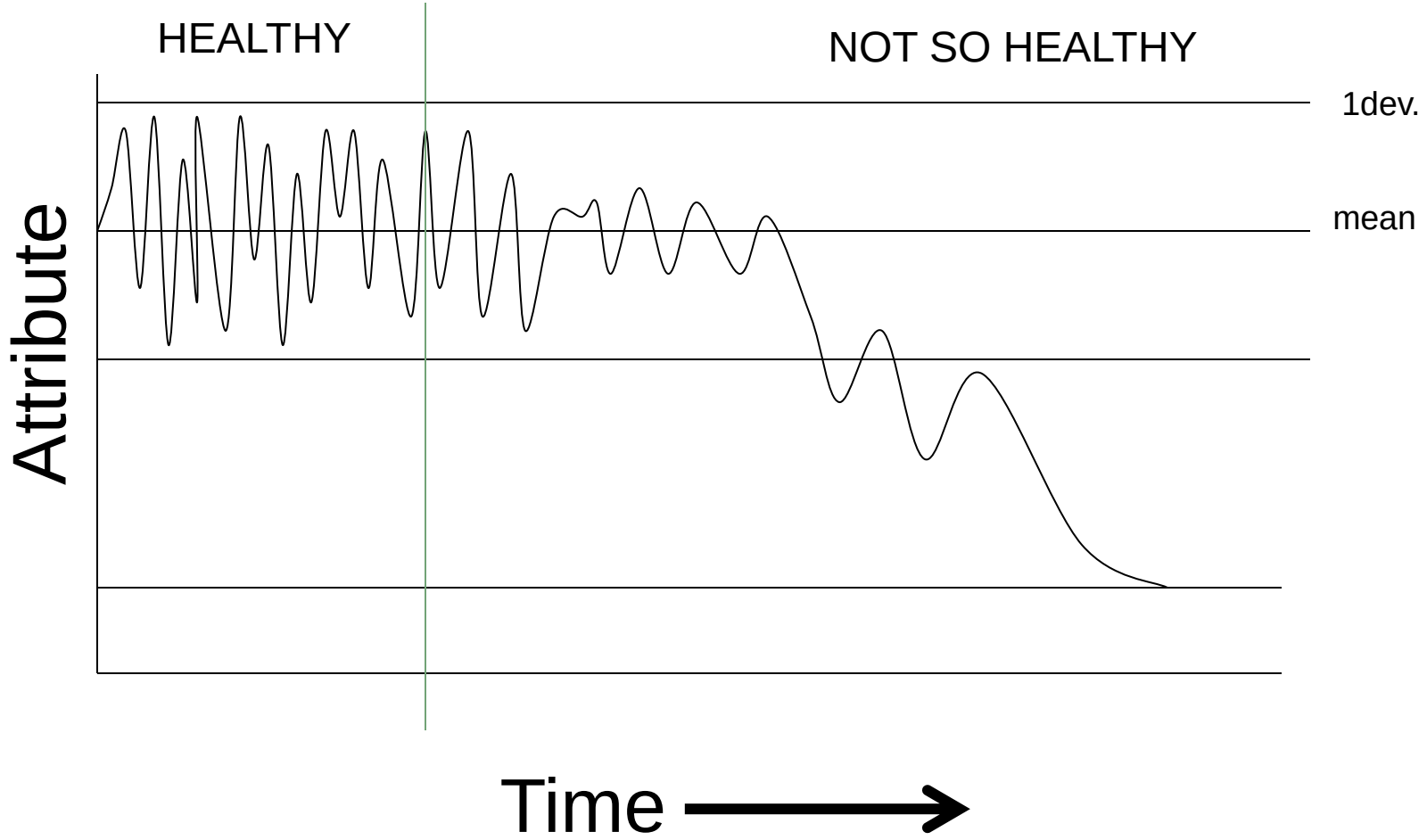
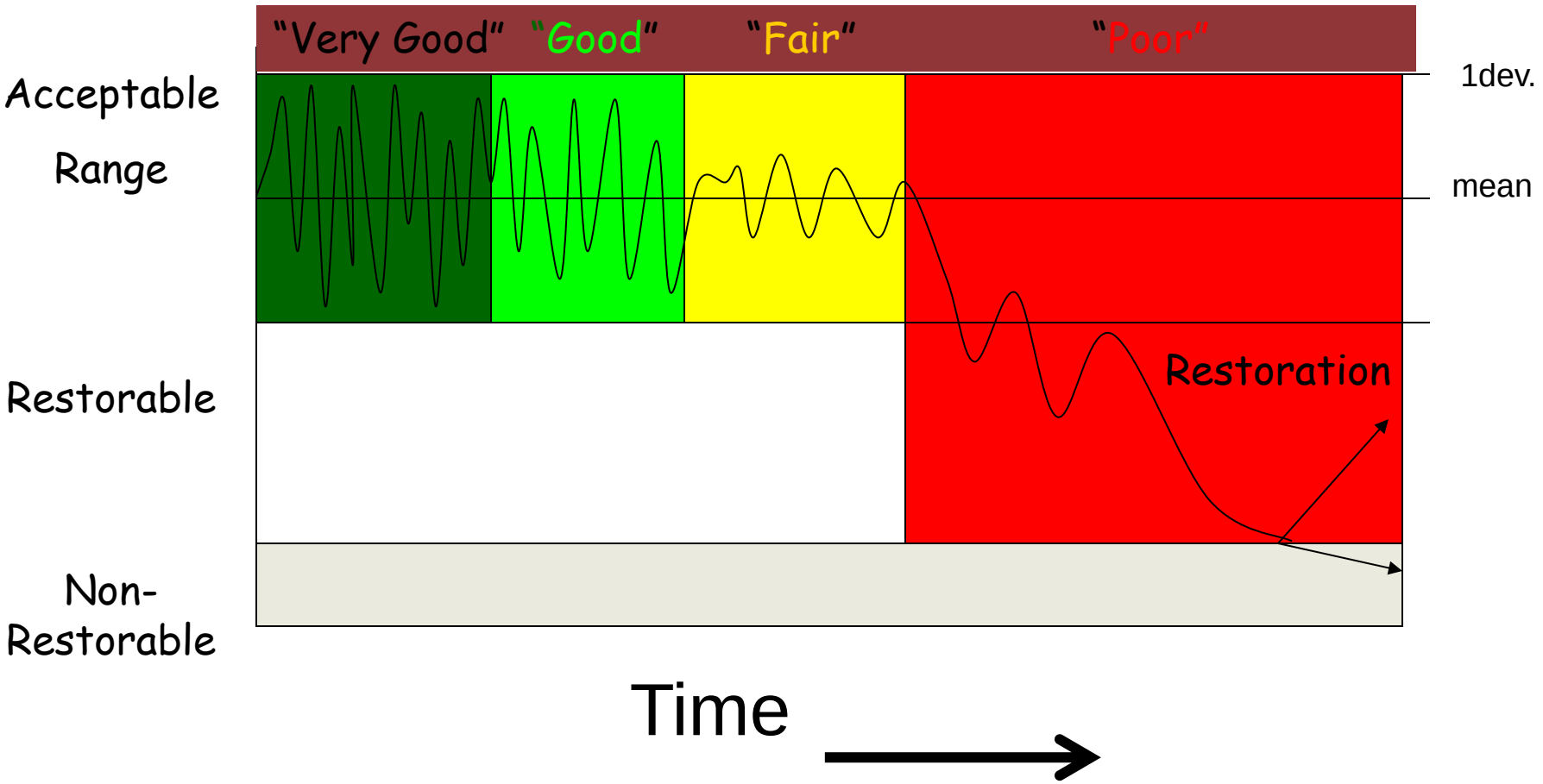
How to describe the desired condition? What should a manager aim to achieve?

- Species, communities, ecosystems evolved within dynamic environments, and show a range of variation in attributes over time
- Variation may be patterned or random
- Variable time scales; may change
- Dynamic template for persistence, evolution

Attribute Range of Variation



Range of Variation & planning



Value of NRV

- Knowledge of natural variation informs goals and evaluations of current conditions, but may not constrain objectives

- Alternative? Make *de novo* decisions about all desired conditions (composition, structure, processes)…but on what basis?

- Is it possible to define thresholds of acceptable (if not natural) RV? Do we already see levels of key attributes that are associated with resource degradation?

Coarse filter/fine filter Approach

- Ecosystems first, species secondarily
- If major ecosystem are managed/preserved in sufficient area and configuration, what species may be missed?
  - additional foci for planning and management.

Basic assumptions: ecological integrity ensures sustainability; management can achieve ecological integrity…

- Ecological values, including biological diversity
- Forest products
- Ecosystem services
  - Supporting (nutrient cycling, primary production)
  - Provisioning (timber, fish, food crops)
  - Regulating (climate, water supply, soil quality)
  - Cultural (aesthetic values)
- Recreation opportunities

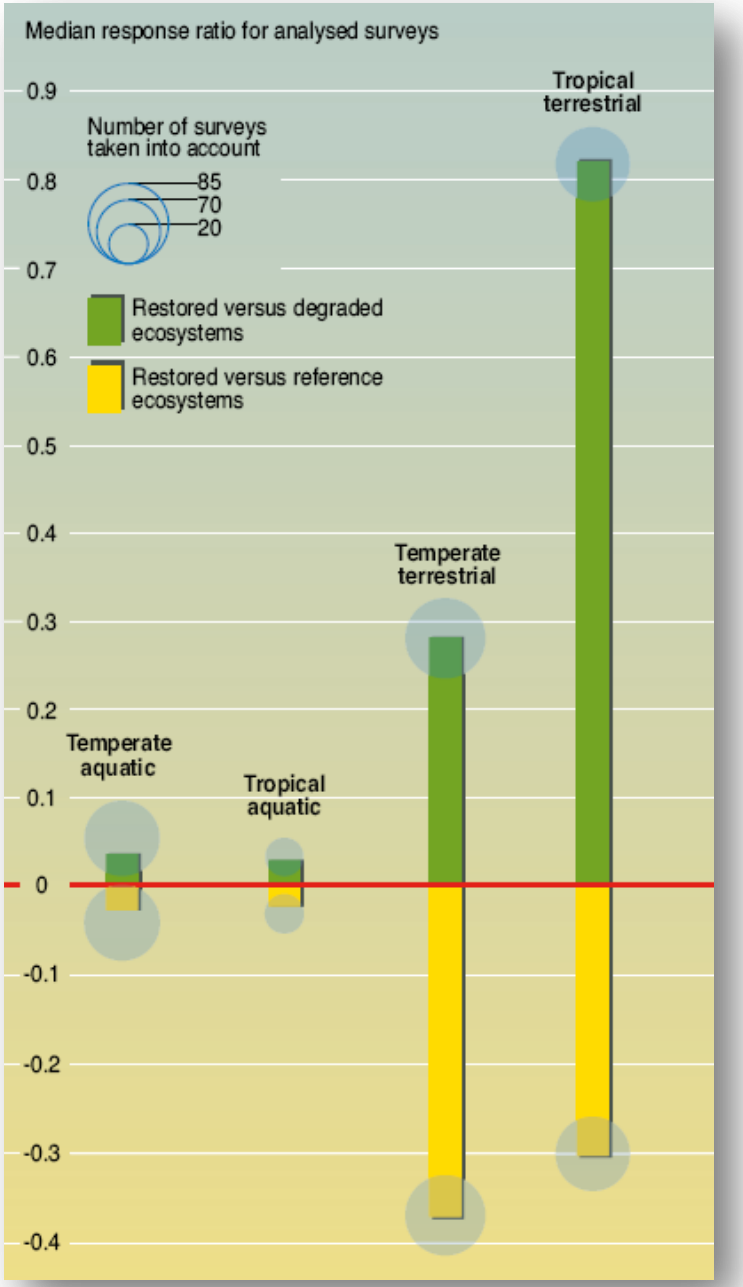
Meta-analysis: Restoration, biodiversity, ecological services

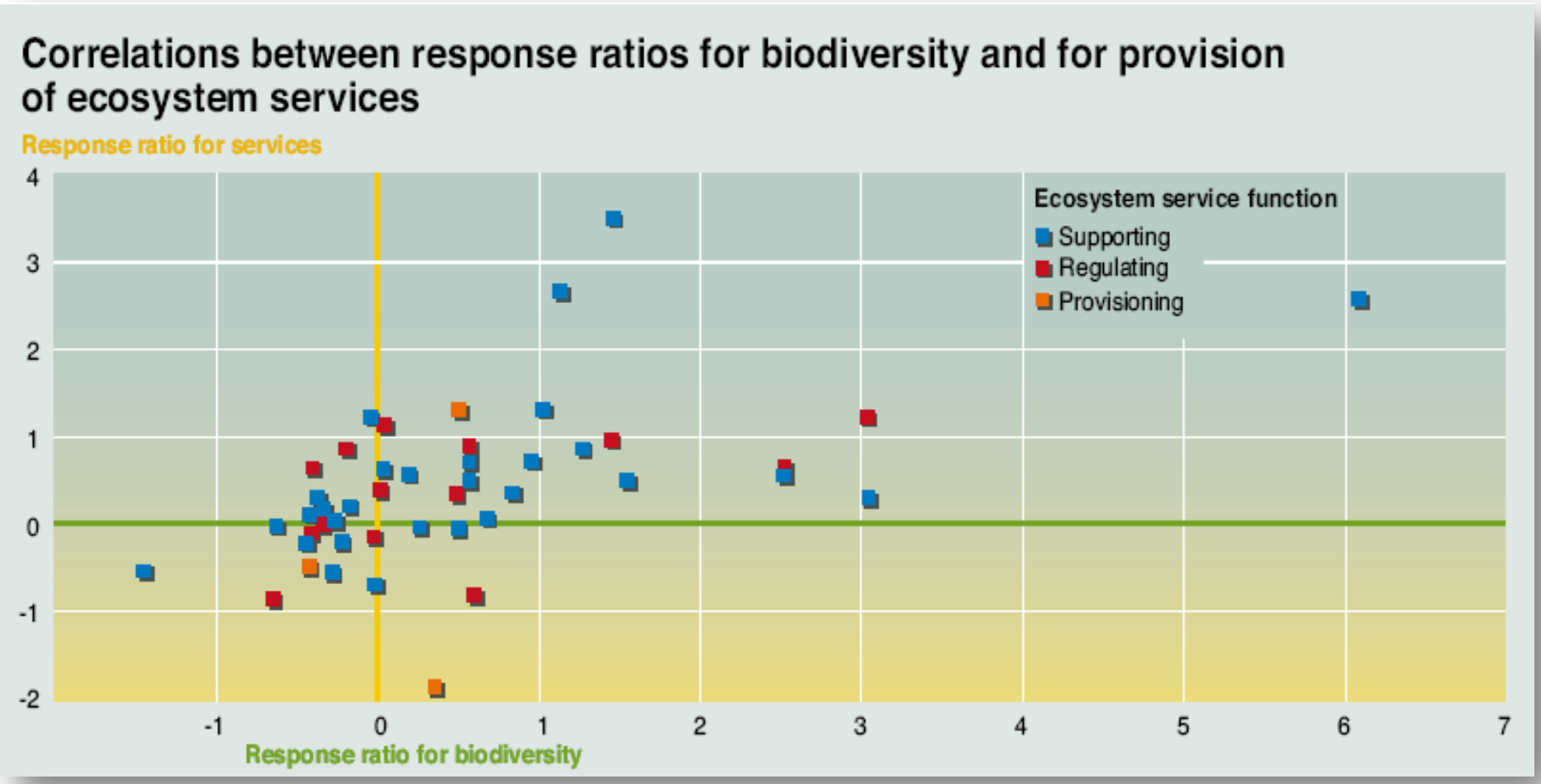
- Benayas et al. analyzed results of 89 studies with multiple measures of biodiversity and ecosystem services

- Findings:
  - Restoration increased provision of biodiversity and ecosystem services by 44 and 25%
  - Both remained lower in restored versus reference systems

Ecosystem services responses to restoration for different biomes

- Restored sites exceeded degraded sites
- But restored sites were inferior to reference sites
- Biggest response tropical terrestrial systems





Restored biodiversity correlated with ecological services delivery

Beneyas et al 2009

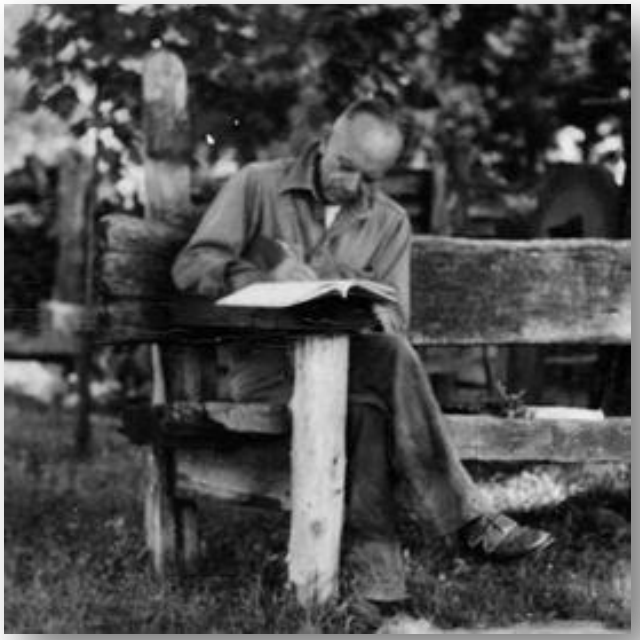
Challenges

- Wide diversity of species, communities, systems, but cannot manage for each individually
- Manage in a way to allow natural ecological and evolutionary processes to play out, landscapes remain dynamic
- Address impacts from human alterations to landscapes, regions (invasive species, climate change)
- Limited knowledge (NRV, ecology, role of disturbance, response to stressors)

- Focus on ecological integrity with understanding based on best available science – a pretty good framework

- *The last word in ignorance is the man who says of an animal or plant: 'what good is it?'. If the land mechanism as a whole is good then every part is good whether we understand it or not. If the biota in the course of eons has built something we like but do not understand then who but a fool would discard seemingly useless parts. To keep every cog and wheel is the first precaution of intelligent tinkering*. (Leopold 1953).

Questions?



Concepts to include

- Resilience, resistance
- Scale
- Restoration
- Disturbance
- Coarse, fine scale approach
- Biodiversity
- Ecosystem services

Stressors…

- A factor that may directly or indirectly degrade or impair ecosystem composition, structure or ecological process in a manner that may impair its ecological integrity, such as invasive species, loss of connectivity, or the disruption of a natural disturbance regime.

Manage for ecological integrity

- "an ecosystem has integrity when it is deemed characteristic for its natural region, including the composition and abundance of native species and biological communities, rates of change and supporting processes." (Panel on Ecological Integrity, Canadian National Parks, 2000)

- an ecosystem has ecological integrity when "the structure, composition and function of the ecosystem are unimpaired by stresses from human activity; natural ecological processes are intact and self-sustaining, the ecosystem evolves naturally and it's capacity for self-renewal is maintained; and the ecosystem's biodiversity is ensured." (BC Parks Legacy Panel, 1999)

- Common threads…

Key ecological attributes

Terrestrial

- *Hydrology*
- ✓ Precipitation (rain, snow, fog)
- ✓ Soil moisture
- ✓ Surface water - groundwater exchange
- ✓ Snow/ice cover
- ✓ Freeze/thaw

- *Soils Chemistry & Structure*
- ✓ Soil chemistry (organic content, nutrients, other chemicals, gases, salinity)
- ✓ Soil temperature & pH
- ✓ Soil structure & drainage
- ✓ Soil erosion & deposition

Riverine

- *Hydrology*
- ✓ Surface water flow regime
- ✓ Surface water elevation
- ✓ Surface/groundwater exchange
- ✓ Ice cover & transport
- ✓ Spatial extent of disturbances

- *Hydrochemistry*
- ✓ Water chemistry (ions, compounds, gases, salinity)
- ✓ Water temperature & pH
- ✓ Particulate & dissolved organic matter
- ✓ Water turbidity/clarity
- ✓ Plant litter & mineral inputs
- ✓ Solar and geothermal inputs

Statistical Model – local scale richness